Which Beneficiation Process is Right for Your Plant?

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SUMMARY

Enough is known about beneficiation technologies to understand how these processes work, how flyash responds to efforts to beneficiate it, and what general results should be expected. This paper attempts to assist flyash producers in grasping the variety of beneficiation processes. A generic description of the various beneficiation concepts and expected results from various technologies is presented.

A few flyash beneficiation technologies have been brought to commercial application. These have enjoyed success for good reasons: their developers have pursued the technologies through diligent investigation and development, they have had the keen interest, support, and commitment of a demonstration host, and they have had funding adequate to weather the lab, pilot, and demonstration phases. These commercial processing technologies are very suitable in many circumstances.

Some applications may require some creativity to find a cost-effective solution. Though a number of these processes await an enthusiastic host and development funding, it is probably safe to say that none of these will prove to be the flyash beneficiation panacea. But, one of these emerging technologies, or perhaps a combination of them, might provide a cost effective solution for your situation.

Armed with this knowledge and a good understanding of the flyash market forces, a flyash producer should be able to sort through the broad number of possible processes and identify those most likely to be effective for their flyash situation. Once several likely processes have been identified, some straightforward characterization tests can be chosen to narrow the field of technologies to those most

promising. Selection, analysis, and interpretation of characterization tests are, of course, a critical part of finding the best flyash beneficiation solution.

Flyash Beneficiation Methods

Flyash is mostly mineral matter. Since mineral matter is desirable for flyash utilization, carbon is often considered a contaminant. In some uses, carbon is simply an unwanted “impurity” but in many cases it influences the quality of the final product. The most common "faults" of carbon include:

< Adding unwanted color (black)
< Adsorbing process or product materials (e.g. water and chemicals)
< Carrying unwanted chemicals into the process (e.g. ammonia)

Since the most plentiful use of flyash is in concrete products, and carbon can cause an increase in water and air entraining agent (AEA) use in concrete, the focus of most beneficiation methods has been to minimize the negative effects that carbon can have in normal-strength concrete.

The following contains a description of the attributes of the various beneficiation approaches. These attributes and shortcomings should be kept in mind while evaluating which beneficiation method appears to be best suited to improve a given flyash.

Passivation vs Removal

In the last two years studies by academic researchers have revealed several important characteristics of carbon normally found in coal flyash. Their findings suggest strongly that carbon in flyash can be made passive to air entraining agents. The best approach to passivation depends somewhat on surface area and porosity characteristics of the carbon, which would be specific to each generating unit and coal. In general, carbon in flyash is made passive by introducing a chemical (either liquid or gas) to the flyash, which is adsorbed onto those carbon sites otherwise competing for the AEA. By occupying these adsorption sites before exposure to an AEA, it minimizes AEA consumption.

While passivation may work well in reducing AEA consumption, it does not control the carbon content of flyash to levels specified by ASTM.

A different approach to beneficiating flyash is to remove carbon from the mineral in flyash. This approach assumes that if enough carbon is removed, the bulk of the remaining flyash will have little carbon and therefore its negative influence will be minimized.

Carbon removal does not directly address the adsorptive characteristics of the carbon. Some flyash carbons have proven to be extremely adsorptive even at LOI levels which meet ASTM specifications. Some carbon removal techniques may alter chemical or physical characteristics of the mineral matter while removing carbon.

Combustion vs Separation

Combustion methods remove carbon without removing the mineral constituents. If the goal of flyash beneficiation is to produce high quality mineral matter, combustion methods accomplish this in a way that eventually places all mineral matter into the final product. These methods sometimes reduce the adsorptive characteristics of any remaining carbon, either by encapsulating it within mineral or by consuming the most reactive carbon. With combustion methods, it is possible to have net energy released from the beneficiation process. Conceivably, this energy gain could be harnessed to improve the overall efficiency of the process.

All separation methods produce more than one stream of products. This means that a use for more than one flyash product needs to be found. If a high-value use for carbon is available, these methods could make a carbon-enriched product stream. Generally none of these streams of products is pure; most contain some carryover of undesirable constituents. Processes with one feed stream and multiple output streams can often be difficult to control by simple methods. In order to attain high purity and consistent product streams, multiple separation process steps are often necessary.

Wet vs Dry

Wet separation methods can be very effective; they can make reasonably sharp separations of certain flyash constituents. They can readily produce multiple products, such as cenospheres, iron oxides, carbon, and pozzolans, to reasonably high degrees of purity. Usually final products are required to be dry so these methods require a large energy expenditure to filter and dry the various products after separation. These methods usually require consumption of additional chemicals to assist wet separation. With some flyashes, wet methods may affect the chemical characteristics of the mineral matter, especially pozzolanic activity. Wet separation methods often require a new, and sometimes large, facility footprint.

Dry methods appear to produce less sharp separation and may not be as suitable for separating multiple products from flyash. These methods all use some energy to accomplish their separation, though not as much as wet methods. They generally require a smaller footprint than wet processes. They may also alter the physical or chemical makeup of the primary mineral product by preferentially removing certain minerals or certain size particles.

Air Classification vs Vibratory vs Electrostatic vs Sieve

Air classification methods often utilize off the shelf equipment. Separation, whether by fluidization or centrifugal action, is accomplished by attempting to manipulate the aerodynamic drag and density characteristics of differing particles. Sharp separation of carbon appears to be difficult with these methods, especially if the flyash has a very large percentage of material with very small particle size. With very small particles, aerodynamic drag appears to dominate the action of particles entrained in air, so even particles with widely different densities behave similarly.

Flyash found in large quantities, such as hoppers, silos, and landfills often exhibits bulk characteristics that contradict predictions based on particle shape and chemical composition. Researchers have concluded that flyash, particularly very fine flyash, is strongly influenced by interparticle forces.

Vibratory methods assume that moisture bonding and van der Waals attractive forces exist between very fine carbon and mineral particles and that these adhesive/attractive forces can be broken by physical vibration. They attempt to cause carbon and mineral constituents to migrate in different directions due to density, shape, or angle of repose. Because the carbon found in flyash is friable and fragments easily, vibratory methods may reduce the average particle size of the carbon and may release ultra-fine mineral particles previously encapsulated within the carbon. One concern with vibratory methods is that of carbon collection. Vibratory methods often utilize shallow beds of flyash to reduce carbon migration distance through mineral, but in doing so produce a thin layer of carbon on top of a relatively thin layer of mineral. Collecting the carbon without capturing mineral is often difficult.

Electrostatic methods are based on the fact that small particles readily pick up surface electrical charges due to interparticle and wall collisions. They also assume that carbon and most mineral matter charge opposite in polarity. Lastly they assume that electrostatic forces are much stronger than other forces of influence on the particles. When these triboelectrically charged particles are exposed to a high intensity electrostatic field, carbon and mineral particles tend to be attracted to oppositely charged electrodes. These methods attempt to capture and remove the particles, once attracted to an electrode. The performance of these methods appears to be sensitive to varying flyash resistivity, which can change significantly from coal to coal. Performance also appears to be quite sensitive to charge dissipation influences, such as relative humidity and high carbon content. These methods appear to alter the size distribution and chemical composition of the flyash, primarily by carrying very fine mineral and iron oxides to the same electrode as the carbon.

Sieving separation of carbon from mineral is dependent on mineral matter having a different average particle size than carbon. Sieving is most frequently assisted by some form of vibration of the screens. Performance of the processes is often affected by vibration motion (for example circular vs lateral) and vibration frequency. Laboratory testing to determine optimum screen configurations, vibratory motion, and vibratory frequency is prudent prior to final equipment selection or installation. Vibration amplitude and duration of exposure are important parameters, as well, to minimize carbon fracture during sieving. With fine powders, it is important to include a stack of sieves upstream of the final sieve in order to avoid blinding of the fine mesh by large particles. Large capacity, fine, industrial sieving processes are not common.